A STUDY OF THE INFLUENCE OF QUALITY OF PROTEIN ON WATER NEEDS IN RATS AND SWINE

BY

UPSON STANLEY GARRIGUS

B. S., University of Connecticut, 1940
M. S., University of Illinois, 1942

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1948

URBANA, ILLINOIS
1948

A STUDY OF THE INFLUENCE OF QUALITY OF PROTEIN ON WATER NEEDS IN RATS AND SWINE

BY

UPSON STANLEY GARRIGUS

B. S., University of Connecticut, 1940
M. S., University of Illinois, 1942

R. UNIV.
BIBLIOTHEEK
LEIDEN

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1948

URBANA, ILLINOIS
1948

ACKNOWLEDGMENTS

The writer wishes to acknowledge with gratitude the valuable instruction received from various members of the Graduate Faculty of the University of Illinois under whom he has studied, especially those in the Departments of Animal Science and Agronomy.

Acknowledgment is made in particular to the following: Dr. H. H. Mitchell for directing attention to the problem; the writer's advisory committee, Dr. W. E. Carroll, chairman, Dr. T. S. Hamilton and Dr. J. L. Krider for advice and aid freely given; Professor H. W. Bean for guidance and assistance in applying statistical treatment to the data; Dr. W. G. Kammlade for considerate adjustment of the writer's work to facilitate the carrying out of this study.

The willing assistance of W. T. Haines in the Animal Nutrition Laboratory and R. H. McDade at the Swine Farm is appreciated.

Appreciation is also expressed to the following: The Western Condensing Company, Appleton, Wisconsin for supplying the lactalumin; Dr. A. L. Whiting, The Urbana Laboratories, Urbana, Illinois for supplying the peas; The Dow Chemical Company, Midland, Michigan for supplying dl-methionine; The A. E. Staley Company, Decatur, Illinois for processing two of the rations used; and to E. I. DuPont de Nemours Company, Wilmington, Delaware for supplying dl-lysine.

The encouragement and sacrifices of the writer's wife and daughter were a continuing inspiration throughout this study.

A STUDY OF THE INFLUENCE OF QUALITY OF PROTEIN ON WATER NEEDS IN RATS AND SWINE

The use of protein in building body tissue requires approximately three grams of water for each gram of protein deposited, but when a gram of protein is catabolized and excreted in the urine, approximately twelve grams of water are simultaneously excreted, as indicated by Adolph (1). Since the excretion of nitrogenous products is greater in the metabolism of proteins of low biological value than in proteins of higher biological value, presumably the feeding of lower quality proteins also increases the water needs.

The purpose of this investigation was to determine whether the quality of protein in a ration influences water needs in rats and swine, and under what conditions such an influence might be studied. If a relationship can be shown with sufficient exactness for prediction purposes, protein quality might be evaluated by measuring water consumption and growth under specified, standard conditions. Investigators would then have a simpler and less expensive means of measuring protein quality than is provided by methods in current use.

In the development of this study, tests in sequence were used. Student's (6) method of analysis for paired data and Fisher's (3) table were used to evaluate the significance of the results obtained.

To determine a technique for studying the influence of protein quality on water needs, a preliminary experiment was conducted with rats. Three different relationships of feed (the feed differing only in the quality of protein) to water consumption were tested with three sets of similar rats, using modifications of the paired feeding technique. In one set, pairs were fed equal feed with water ad libitum; a second

set received both feed and water ad libitum; a third set received feed ad libitum but pairs were limited to an equal water ration at a restricted level. Data on feed and water consumption and on gain in weight were collected. Length from nose to base of tail and weight of the contents of the alimentary tract were obtained on all rats. The kidney weights and the nitrogen and dry matter content were taken of composite samples of the respective pair members from the equal food and ad libitum water test. Results were as follows:

1. In the equal feed and ad libitum water test, rats on the better quality protein diet; (a) drank more water; (b) made greater gains; (c) used more water per unit of feed consumed; (d) used less water and feed per unit of gain in weight; (e) had more material in alimentary tract at termination of experiment; (f) had greater body length; (g) had no significant difference in kidney weights; (h) had no significant difference in nitrogen and dry matter content of composite sample.

2. In the ad libitum feed and water test, rats on the better quality protein diet; (a) consumed more feed; (b) drank varied amounts of water; (c) made greater gains; (d) used varied amounts of water per unit of feed consumed; (e) used less water and feed per unit of gain in weight; (f) had more material in the alimentary tract at termination of experiment; (g) had greater body length.

3. In the ad libitum feed and equal water test, rats on the better quality protein diet; (a) consumed more feed; (b) made greater gains; (c) used less water and feed per unit of gain in weight; (d) had more material in alimentary tract at termination of experiment; (e) had greater body length; produced water/feed and water/gain ratios, the product of which was smaller than that on either of the other tests.

To determine what level of water and feed intake could be considered normal for growing-fattening swine, individually

fed in small pens, six pairs of pigs were individually fed, ad libitum, a good growing-fattening ration with water. Results were as follows:

Pigs under conditions imposed: (a) consumed feed at a rate which more closely approximated the data obtained by Evvard (2) than that compiled by Smith (5); (b) consumed approximately 1.8 to 1.9 times as much water as feed by weight.

To determine what level of water intake would reduce luxury use of water and yet permit a gain of approximately one pound a day, various restricted levels of water intake were imposed. The restriction levels were established as percentages of the product of 1.9 and the calculated, full-feed-consumption figures, estimated from a regression equation based on Evvard's data. Results were as follows:

Pigs on a water level of fifty percent of the calculated, full ad libitum consumption: (a) consumed less water per unit of feed consumed; (b) consumed slightly less feed; (c) made slightly smaller gains but maitnained reasonable gains.

To determine how relationships of gain in weight, feed consumption and water consumption differ in growing-fattening swine, under conditions of equal water intake, where rations fed are nearly alike except for the quality of protein, a further test was made. Six pairs of pigs were fed ad libitum. Water rations were restricted to 22.5 percent of $Weight^{2/3}$, which approximated the fifty percent level previously determined and had the advantage of being associated with a more directly measurable base. Results were as follows:

Pigs on better quality protein ration: (a) consumed more feed; (b) had greater gains in weight; (c) used less water per unit of feed consumed; (d) used less water and feed per unit of gain in weight.

To determine the biological value of rations which differed

only in the relative amounts of lysine, half-grown rats were used (4). The rations were similar to rations used in an earlier swine test in which lactalbumin was substituted for part of the basal ration to improve the lysine content. The addition of dl-lysine eliminated the possibility, present in the earlier test, that only factors other than the quality of protein were changed by the inclusion of lactalbumin in the supplemented ration. The basal ration with the addition of dl-lysine proved to have a slightly higher biological value than the unsupplemented ration.

Conclusions

Under the conditions imposed in this study of the influence of the quality of protein on water needs in rats and swine, the following conclusions seem justified:

1. The best technique to determine the influence of quality of protein on water needs in rats, of those studied, is that in which the rats receive feed ad libitum and are limited to equal, restricted water rations.

2. Young growing-fattening swine will consume, ad libitum, approximately 1.9 times as much water as feed, which product may be used as an estimate of full water consumption.

3. Luxury use of water is reduced by restricting the water ration to fifty percent of the calculated, full, ad libitum, consumption figure; feed consumption and gains in weight are slightly reduced, yet reasonable gains are maintained.

4. When paired, growing-fattening swine receive water rations which are restricted to 22.5 percent of the two-thirds power of the average pair weight and are fed, ad libitum, rations similar except for quality of protein, the pair members receiving the better quality protein ration will make larger gains on smaller amounts of water

and feed per unit of gain.

5. The results obtained from the ad libitum feed and equal water test with rats and from a similar test with swine are strongly indicative that an influence of quality of protein on water needs does exist.

6. The results of this study suggest that further investigation of the influence of quality of protein on water needs would be desirable. An approach similar to that developed in this study, using comparable animals fed rations alike except for quality of protein, with the application of an analysis of volume, concentration and composition of urine, should yield results which would add substantially to the understanding of this problem.

REFERENCES

1. Adolph, E. F., 1933. The metabolism and distribution of water in body and tissues. Physiol. Revs. 13:336-371.

2. Evvard, J. M., 1929. A new feeding method and standards for fattening young swine. Ia. Agr. Expt. Sta. Res. Bul. 118:p.273.

3. Fisher, R. A., 1925. Expansion of Student's integral in powers of n^{-1}. Metron. 5:105-120.

4. Hamilton, T. S., 1947. The Illinois method for determining the biological value of proteins. U. of Ill., An. Husb. Mimeo. 1636:6 pp.

5. Smith, W. W., 1937. Pork Production. Macmillan Co., New York, N. Y. p. 143.

6. "Student.," 1908. The probable error of a mean. Biometrika 6:1-25.

VITA

Upson Stanley Garrigus was born in Willimantic, Connecticut July 2, 1917.

Institutions attended: Grade schools of Town of Mansfield, Tolland County, Connecticut, 1924-1932; Windham High School, 1932-1936; University of Connecticut 1936-1940; University of Illinois, 1940-1942 and 1946-1948.

Degrees: B. S., University of Connecticut, 1940; M. S., University of Illinois, 1942.

Positions held: Assistant in Animal Science, University of Illinois, 1940-1942 and 1946-1948 (on leave for military service 1942-1946).

Honors: Sigma Xi, Phi Kappa Phi, Gamma Sigma Delta and Phi Sigma.